



# PATENT SPECIFICATION

Convention Date (Switzerland): May 4, 1938.

527.025

Application Date (in United Kingdom): March 28, 1939. No. 9670/39.

Complete Specification Accepted: Oct. 1, 1940.

## COMPLETE SPECIFICATION

### Improvements in or relating to Heating Apparatus for the Cabins of Aircraft

We, SULZER FRÈRES SOCIÉTÉ ANONYME, a Company organised under the Laws of Switzerland, of Winterthur, Switzerland, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to heating apparatus for the cabins of aircraft.

Very many proposals have been hitherto made to use the heat of the exhaust gases for heating the interior of vehicle bodies, but in the case of aircraft cabins water or steam has hitherto been employed for this purpose.

According to this invention heating apparatus for aircraft cabins comprises a heat exchanger by which heat is transmitted in the known manner to air, which in turn serves to transmit heat to the air used for heating the cabins.

Preferably the apparatus includes a primary heat exchanger for transmitting heat from the exhaust gases to intermediate air acting as a heat carrier and a secondary heat exchanger for transmitting heat from the intermediate air to the air employed for heating the cabin or cabins.

In such an arrangement the intermediate air conveniently flows from the atmosphere and is forced through the heat exchangers by pressure, preferably by pressure automatically obtained when the aircraft is in flight. Further, the air used for heating the cabin or cabins conveniently enters through an inlet opening arranged at a point in the skin of the aircraft where excess pressure is obtained during flight so that the flow of this air is effected during flight without the employment of separate pumping apparatus.

The primary heat exchanger preferably comprises a jacket surrounding a part of the exhaust pipe which can thus be of normal construction in order that the resistance to flow through the exhaust pipe may not be increased by this heat exchanger.

The secondary heat exchanger may comprise, for example, two pipes, one within the other, the intermediate air

being conveyed through the inner pipe while the air used for heating the cabin or cabins is fed through the annular space between the inner and outer pipes. In any case such secondary heat exchanger may be disposed in a cabin to be heated.

Further, the secondary heat exchanger may be subdivided into two or more sections such that the heat exchange surface for the air delivered to the cabin or cabins through the outlets more remote from the point at which the intermediate air enters the heat exchanger is greater than that for the air flowing to the outlets lying nearer the end of the heat exchanger at which the intermediate air enters it.

In any case the heat exchange surface of any heat exchanger employed according to the invention may be provided with longitudinal corrugations.

Again, an ejector utilising atmospheric air may be arranged in the pipe for delivering air to the cabin or cabins to be heated, this ejector serving to draw air from one or more of such cabins.

The invention may be carried into practice in various ways but one arrangement according to the invention is diagrammatically illustrated in the accompanying drawings, in which Figure 1 is a diagrammatic view of the complete apparatus,

Figure 2 is a diagrammatic view on an enlarged scale of a secondary heat exchanger arranged in one of the aircraft cabins, and

Figure 3 is a section on the line 3—3 of Figure 2.

In the construction illustrated, the aircraft comprises a body 1 supported by planes 2 carrying engine rooms 3 and 4 containing internal combustion engines, the engines themselves for the sake of simplicity not being shown. The reference numeral 5 indicates the pilot's cabin, the numeral 6 a further cabin, for example an entrance cabin or luggage space, and the numeral 7 the passenger cabin.

For the sake of simplicity the apparatus will first be described as applied to one engine only. The engine is provided

with an exhaust pipe indicated at 8 which opens at 10 to the atmosphere and is surrounded by a primary heat exchanger 11 constituted by a jacket surrounding part of the exhaust pipe 8 so that the surface 9 of the exhaust pipe acts as the heat exchange surface.

Communicating with the forward end of the interior of the heat exchanger 11 is an inlet opening 12 for intermediate air while the after end of the heat exchanger 11 communicates with a pipe 13 extending through the interior of the plane 2. The pipe 13 divides into two pipes 14, 15 which are coupled to the inner pipes 16 and 17 of secondary heat exchangers 18 and 19 each comprising concentric inner and outer pipes, the inner pipes 16 and 17 terminating in outlets 21, 22 opening to the atmosphere.

At the front part of the body 1 of the aircraft where there is excess pressure when the aeroplane is flying, is provided an inlet 23 for the air used for heating the cabins. Leading from the inlet 23 is a pipe 24 provided with a control valve 25 and communicating through branches 26 and 27 and the outer pipes of the heat exchanger 18 and 19 with outlet nozzles 28, 29 and 30, 31 opening into the cabin 7. A pipe 32 controlled by a valve 41 leads from the heat exchanger 19 into the pilot's cabin 5.

Further, an ejector 33 having a nozzle 34 is arranged between the pipes 24 and 26, 27 and communicates through a pipe 35 controlled by a valve 43 with the cabin 7.

The inner pipes 16 and 17 of the secondary heat exchangers 18 and 19 may be plain but are conveniently provided with longitudinal corrugations, as shown in Figures 2 and 3, while moreover the space between the inner and outer pipes 16 and 17 of each of these heat exchangers may be subdivided, as shown in Figures 2 and 3, by partitions 37 so that the heat exchanger is divided into two chambers 38 and 39. The outlet nozzles 28 and 30 communicate with the smaller chamber 38 while the outlet nozzles 29 and 31 communicate with the larger chamber 39, these nozzles preferably being controllable by means of throttle valves 40.

Communicating with the pipe 13 is a pipe 46 leading to the atmosphere and controlled by a valve 45.

The operation of the apparatus is as follows. Atmospheric air entering through the openings 12 flows along the heat exchange surface 9 of the heat exchanger 11 and is heated to an extent dependent upon the area of the heating surface and the temperature of the exhaust gas which may be, for instance,

450° C. In this way the air may be heated, for example, to 200° C. This intermediate air passes through the pipes 13, 14 and 15 into the inner pipes of the secondary heat exchangers 18 and 19 where it gives off heat to the heat exchange surfaces constituted by the pipes 16 and 17 before flowing through the outlets 21 and 22. Over the outside of the pipes 16 and 17 flows air which enters through the opening 23 and flows through the pipes 24, 26 and 27. This air will thus be heated to the required extent, for example to 35° C. and will enter the cabin 7 through the nozzles 28, 29, 30, 31 so as to heat this cabin.

The nozzles 28, 29, 30, 31 are conveniently so arranged, for example under the seats, that on the one hand any inconvenience to the passengers is avoided and, on the other hand, the temperature in the cabin can be quickly and completely rendered uniform. Waste air escapes from the cabin 7 through waste air openings, indicated at 44. It will be seen that the heating at individual points can be regulated by setting the valves 40 appropriately. Further, where the secondary heat exchanger extends through two or more cabins, the valves 40 can be used to regulate the heating in individual cabins. In any case, the maximum opening may be different for different nozzles, either for the purpose of obtaining approximately the same discharge of air through the front nozzles as through the rear nozzles or for otherwise determining the maximum discharge of air through the individual nozzles to suit requirements.

The heating of the pilot's cabin is effected by air delivered through the pipe 32 and can be regulated by control of the valve 41.

It will be appreciated that the full output of heat can only be obtained during flight with the engine or engines under power. Thus, when gliding with the engine or engines shut off, the pipe 24 is preferably closed by the valve 25. Even when, however, the aircraft is still, a certain degree of heating in the cabin 7 will be obtained as soon as the engines are started since under the action of the propellers air will be forced through the inlet openings 12 so that hot air will be delivered through the pipes 13, 14 and 15 to the pipes 16 and 17 and the heat given off by these pipes will contribute to some extent to heating the cabin since the heat exchangers 18 and 19 are arranged within or adjacent to the cabin to be heated, for instance under the flooring of the cabin.

When it is desired to obtain rapid heating, for instance when the atmos-

pheric temperature is exceptionally low. the ejector 33 may be brought into operation by opening the valve 43. Thus, by means of this ejector it is possible by reason of the suction created by the nozzle 34 to draw in air through the pipe 35 so that air from the cabin 7 is circulated through the heat exchangers 18 and 19. In order to regulate the quantity of air drawn in through the pipe 35, the valve 43 may be adjusted or alternatively means may be provided whereby the nozzle 34 can be moved axially so as to vary the suction effect thereof.

It is to be understood that the pressure employed to cause the flow of the intermediate air may, if desired, be produced by means of a fan while moreover the intermediate air may be circulated in a closed circuit by providing return pipes extending from the outlets 21 and 22 to the openings 12.

For ensuring greater heating reliability in the case of multi-engine aircraft, a primary heat exchanger may be associated with each of the engines or with alternate engines, the pipes 13 from these heat exchangers opening into a common main pipe, as indicated in Figure 1 for two engines, so that in the event of failure of one engine, heating, even though somewhat more limited heating, of the aircraft cabins will still be possible. Such an arrangement has the advantage that it enables comparatively small pipes to be employed, which facilitates the installation of these pipes.

In hot weather the apparatus according to the invention may also be used for cooling the cabins by closing the valve 42 so as to cut off the supply of hot air from the heat exchanger 11, whereupon cold fresh air can be introduced into the aircraft cabins through the pipes 24, 26 and the nozzles 28, 29, 30 and 31 and the pipe 32. When the valve 42 is closed the valve 45 may be opened so that cool air passes over the heat exchange surface of the heat exchanger 11 so that over- heating of this surface is prevented even when no heating of the cabins is taking place and the life of the heat exchanger 11 thus lengthened.

In known heating apparatus for aircraft water or steam is used to transmit the heat, the exhaust gases in the latter case heating an evaporator the steam from which heats in a condenser the fresh air to be supplied to the aircraft cabin or cabins, the condensate from the condenser returning to the evaporator. In this type of apparatus there is risk of freezing while moreover when the aircraft tilts the water is apt to run out of the evaporator so that the evaporator surfaces

exposed to the exhaust gases are liable to become red-hot and then to be brought again into contact with the water so that they are suddenly cooled with the result that the material of which they are formed is subject to high heat stresses which may result in leaking of the evaporator and losses of water.

It will be seen that apparatus according to the present invention has no such disadvantage. Moreover, with apparatus according to the invention it will be seen that there tends to be obtained a uniform heat stressing of all the parts of the heating apparatus and more particularly of the heat exchanger 11 so that the reliability and the life of the installation tend to be increased. Further, the heat exchange surface constituted by the exhaust pipe 8 at least is preferably made of a heat-resisting material in order to enable it to withstand the high exhaust temperatures.

The apparatus further has the advantage over heating apparatus in which the exhaust pipe is used as a direct heating surface for the cabin or cabins in that the danger of poisoning should the exhaust pipe leak is avoided. Further, the employment of a heat exchanger such as 11 in which the exhaust pipe is merely jacketed does not result in any throttling of the flow of exhaust gas through the exhaust pipes. In some cases nevertheless the heat exchanging surface of the exhaust pipe may be corrugated. The whole installation is further less likely to prove dangerous and the heating is simple to control.

Owing to the greater cross-sectional area of the chamber 39 than the chamber 38 in each of the heat exchangers 18 and 19, the total resistance to flow of the air passing through the forward nozzles 28, 30 may be made approximately the same as that for the air passing through the rear nozzles 29, 31.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Heating apparatus for aircraft cabins comprising a heat exchanger for transmitting heat in a known manner from the exhaust gases to air which in turn serves to transmit heat to the air used for heating the cabins.

2. Heating apparatus for aircraft cabins comprising a primary heat exchanger for transmitting heat from the exhaust gases to intermediate air acting as a heat carrier and a secondary heat exchanger for transmitting heat from the intermediate air to air

employed for heating the aircraft cabins.

3. Heating apparatus for aircraft cabins as claimed in Claim 2, in which the intermediate air flows from the atmosphere and is forced through the heat exchangers by pressure.

4. Heating apparatus for aircraft cabins as claimed in Claim 3, in which the intermediate air is forced through the heat exchangers by pressure automatically obtained when the aircraft is in flight.

5. Heating apparatus for aircraft cabins as claimed in any one of the preceding claims, in which the air used for heating the cabins enters through an inlet opening arranged at a point in the aircraft skin where excess pressure is obtained during flight so that the flow of this air is effected during flight without the employment of a separate pumping device.

6. Heating apparatus for aircraft cabins as claimed in Claim 2, in which the primary heat exchanger comprises a jacket surrounding a part of the exhaust pipe in order that the resistance to flow through the exhaust pipe may not be increased by this heat exchanger.

7. Heating apparatus for aircraft cabins as claimed in Claim 2, in which the secondary heat exchanger comprises two pipes one within the other, the intermediate air being conveyed through the inner pipe while the air used for heating the cabins is fed through the annular space between the inner and outer pipes.

8. Heating apparatus for aircraft cabins as claimed in Claim 2, in which

the secondary heat exchanger is disposed in a cabin to be heated.

9. Heating apparatus for aircraft cabins as claimed in Claim 2 or Claim 7, in which the secondary heat exchanger is subdivided into two or more sections such that the heat exchange surface for the air delivered to the cabins through the outlets more remote from the point at which the intermediate air enters the heat exchanger is greater than that for the air flowing to the outlets lying nearer the end at which the intermediate air enters it.

10. Heating apparatus for aircraft cabins as claimed in any one of the preceding claims, in which the heat exchange surface of the heat exchanger or of one or each of the heat exchangers is provided with longitudinal corrugations.

11. Heating apparatus for aircraft cabins as claimed in any one of the preceding claims, in which an ejector utilising atmospheric air is arranged in the pipe for delivering air to the cabin or cabins to be heated and serves to draw air from one or more of such cabins.

12. The complete heating apparatus for aircraft cabins constructed and arranged substantially as described and diagrammatically illustrated in the accompanying drawings.

Dated this 28th day of March, 1939.

KILBURN & STRODE,  
Agents for the Applicants.

Reference has been directed, in pursuance of Section 7, Sub-section (4), of the Patents and Designs Acts, 1907 to 1939, to Specification No. 305,627.

Fig. 2.

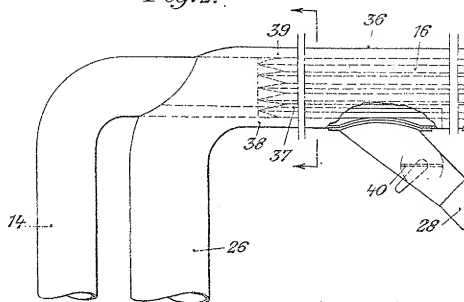
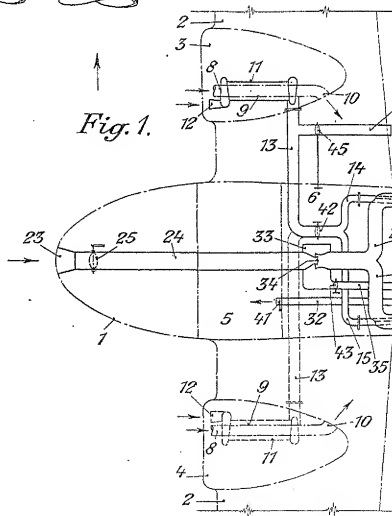


Fig. 1.



[This Drawing is a reproduction of the Original on a reduced scale.]

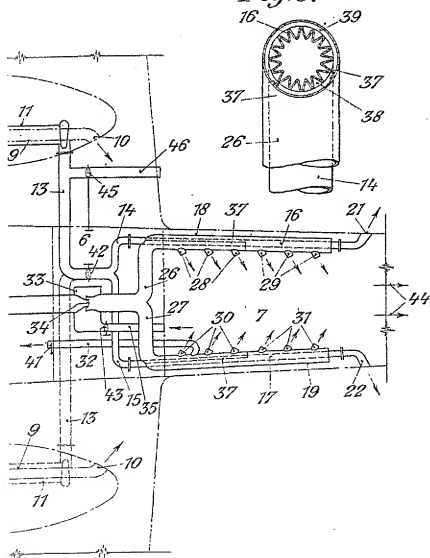
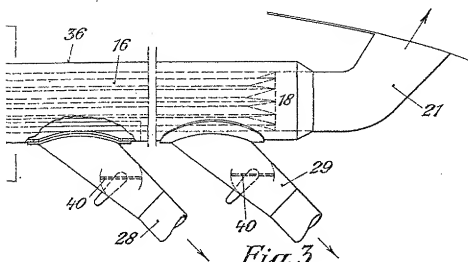


Fig. 2.

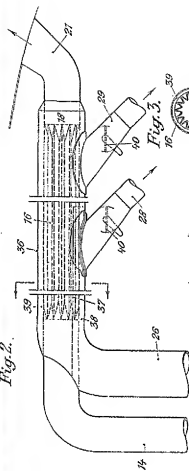
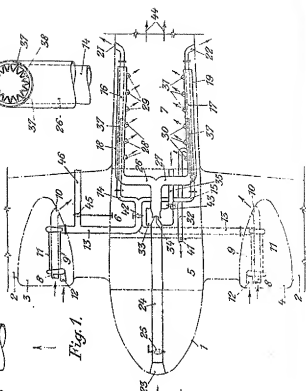


Fig. 1.



[This Drawing is a reproduction of the Original on a reduced scale.]